Mobile User Navigation Supported by WSAN: Full-fledge Demo of the SmartPark System

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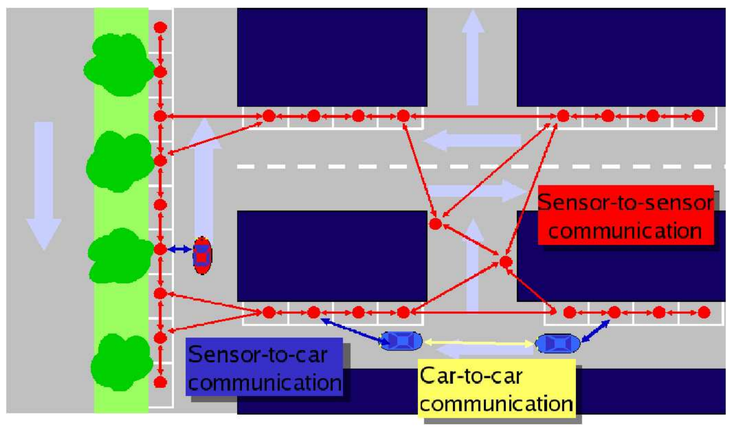
The SmartPark System::http://smartpark.epfl.ch::

- Driver arrives at unknown city
- System automatically identifies parking spots (empty or occupied)
- Wireless guidance device embedded in car (no GPS) provides driver with parking spot availability information
- System guides driver to a chosen empty parking spot

System Elements



- Each parking spot equipped with a wireless sensor
- Wireless guidance device embedded in the car
- Both mobile and fixed nodes form ad hoc Wireless Sensor and Actuator Network
- No central server, no navigation system like GPS
- Vehicle-to-vehicle and vehicle-to-sensor communication used mostly (*inexpensive*)
- Sensor-to-sensor communication allowed (*expensive*)

Research Challenges

- Connecting (possibly) partitioned networks
- Mobility
- Energy scarce in fixed nodes, plentiful in mobile nodes
- Scale of the network
- No full view of whole system (important for discovery and navigation)
- Radio channel uncertainty (fading, interference)
- Efficient conflict resolution methods (an ad hoc reservation system)
- In-network aggregation at different time and space scopes

Building Blocks

Information Dissemination: *Provides users with the up-to-date information about parking spot availability.*

Approach:	Research Challenges:
Epidemic-like dissemination (no need for end-to-end communication)	Bandwidth efficient dissemination algorithms
Connecting isolated city islands (mobile users as data mules)	Mobility forwarding

Current Implementation:

- Each node periodically broadcasts its own state (empty or occupied) sending the $BcastMsg$.
- Nodes (fixed and mobile) can overhear nearby nodes and learn their state.
- Upon each new broadcast, the state of other k nodes is piggybacked on the $BcastMsg$.
- The information about nodes that are far away is brodcast more often than information about the one-hop neighbors. This is done by applying a *selection policy*:
  - Information about one-hop neighbors is selected from the node's cache with small probability p
  - Information about other nodes is selected with high probability $1-p$
  - Only fresh information is selected

Localization and Tracking: *Provides users with location information when without a navigation system like GPS.*

Approach:	Research Challenges:
Constrained tracking (localization on the road graph)	Very heterogenous sensor deployment
Path planning and following (dead reckoning)	Methods resistant to sensor outages and radio uncertainties

Current Implementation:

- Uses both the location information stored at the fixed sensor and the RSS measurements
- Uses the center of mass approach (no constrained tracking implemented at the moment):
  - Exponencially-weighted: include past location estimates
  - RSS-weighted: for nodes that are closer, the RSS is higher

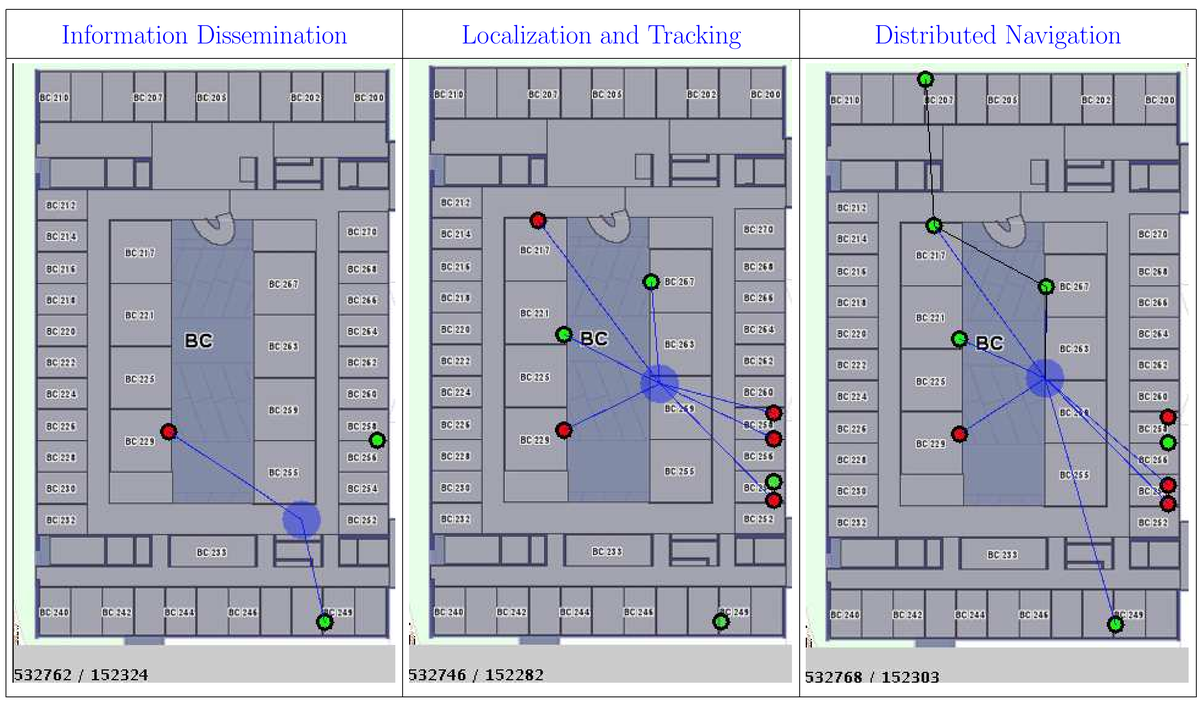
Distributed Navigation: *Provides users with turn-by-turn instructions to the chosen empty parking spot.*

Approach:	Research Challenges:
Computational complexity pushed towards the user	Local view of the system only
Multi mobile design (collaborative resource discovery)	Route selection based on traffic flow estimation

Current Implementation:

- Path to the chosen parking spot *consists* of fixed nodes that should be visited by mobile user sequentially

Example



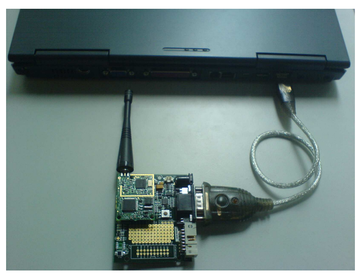
Testbed

Parking Sensor: TinyNode + Standard Extension Board(http://tinynode.com)

Hardware (Features)
TI MSP430 microcontroller
Semtech radio transceiver **XE1205** (868MHz)
Adjustable datarates **up to 153kbit/s**
Out-of-the-box **TinyOS** support

Software (Service Division)
Hardware Abstraction
Sensing
Epidemic-like messaging

Wireless Guidance Device: Laptop/PDA + TinyNode



Software (Service Division)
Epidmic-like messaging
Localization and Tracking
Path Planning
Path Following

Current Status

Deployment at WASAL (http://wasal.epfl.ch) - laboratory for prototyping applications of WSANs:

- Parking sensors: 25 TinyNodes at fixed locations deployed indoors
- Mobile users: 2 Laptop with TinyNodes on trolleys

Test scenarios:	Metrics:
One mobile user at fixed location	Parking spot visibilty: *How many parking spots were visibile within a fixed time window?*
1st mobile at fixed location, 2nd mobile approaching the 1st	Latency of information propagation: *How fast does information about state change propagate?*

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